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CARCASSES OF ADELIE PENGUINS AS A FOOD SOURCE FOR SOUTH POLAR SKUAS: SOME PRELIMINARY OBSERVATIONS

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Abstract.—South Polar Skuas (*Catharacta maccormicki*) take eggs and young of Adélie Penguins (*Pygoscelis adeliae*) by scavenging and predation. We collected carcasses of penguins near Davis, East Antarctica, and examined them for damage and tissue removal by skuas. Progression of tissue destruction and removal was used to indicate successive areas of feeding. Organs and tissues from undamaged, fresh corpses were weighed to determine potential food quantities. Areas of initial attack were around the head. Subsequent damage was concentrated in the thoracic-abdominal regions, and around pelvic limb musculature. Such areas provided 19% (abdominal) and 12% (pelvic muscles) of the body mass. Because seabird eggs and chicks provide as much, if not more, energy as alternative foods (krill, fish) which require extended foraging, it is adaptive for skuas nesting near penguin colonies to forage there. *Received 4 Dec. 1992, accepted 13 May 1993.*

Foods eaten by South Polar Skuas (*Catharacta maccormicki*) vary among sites around Antarctica. In some areas, there may be a reliance on fish (e.g., Young 1963a, 1970; Pietz 1987) or, at coastal or inland sites, on bird species (e.g., Mehlum et al. 1988, Heatwole et al. 1991, Wang and Norman 1993). Elsewhere, as at some sites in East Antarctica, eggs and chicks of Adélie Penguins (*Pygoscelis adeliae*) are important in the skuas' diet. This may be particularly so for skuas with feeding territories near or within Adélie Penguin colonies, but skuas breeding some distance away from colonies may also take penguins (e.g., Green 1986, Norman and Ward 1990). Despite the varying extent to which South Polar Skuas depend on Adélie Penguins as a food source (e.g., Young 1963a, b; Maher 1966; Spellerberg 1975), their role as predators of penguins, particularly of eggs and chicks, has become well-established. However, little attention has been paid to the use that skuas make of penguin carcasses as a food resource, even though alternative foods or foraging strategies may be locally available.

This study describes patterns of feeding from corpses of Adélie Penguin chicks by South Polar Skuas. It includes description of the site of initial attacks, the sequence of tissue and/or organ use, and the subsequent carcass destruction.

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METHODS

During the 1990/1991 austral summer, carcasses of Adélie Penguins were collected at various sites in the Vestfold Hills area and were categorized by plumage as being chicks (guard or post-guard), subadults, or adults. On 4 January 1991, 101 penguin carcasses (damaged or otherwise) were collected in and around a colony on Hop Island (68°50′S, 77°42′E). This sample included 42 with subadult plumage (i.e., not hatched during the 1990/1991 season). A sample of 14 fresh, young chick carcasses was obtained at Hop Island on 8 January 1991. Collections were also made at Hawker Island (68°33′S, 77°51′E; 15 January 1991, 25 recently-dead chicks) and Magnetic Island (68°33′S, 77°54′E; 20 January, four young, four subadult and two adults). All carcasses were examined in detail for evidence of external damage (=skin break) associated with initial (procurement or killing) activities of skuas, and for subsequent disturbance or removal of underlying tissues, organs or body parts. Increased destruction was taken to indicate progressive use of carcasses as a food source (although not necessarily by the same skuas), as was removal of body parts (e.g., head, limbs, etc.). For complete carcasses, damage was assigned to 29 body regions but a further nine categories (including those for missing body parts) were used for incomplete corpses (see Fig. 3). However, in some summaries below, there has been an inevitable need to combine areas of attention.

To estimate potential food available to skuas from parts of penguin carcasses, apparently undamaged, fresh corpses (nine chicks, one adult) were collected at Magnetic Island on 19 January 1991. Each carcass was weighed (to 0.1 g). Pectoral and pelvic limb muscles (one side only, doubled in summaries below), submandibular and ventral cervical soft tissues (including tongue, trachea and esophagus to thoracic inlet), thoracic organs (heart, and lungs with associated major blood vessels), and abdominal organs (intestinal tract, complete stomach, liver and spleen, kidneys, adrenals and gonads) were removed and weighed separately (to 0.01 g).

For carcasses with damage, the locations of skin breaks and tissue and organ removal were examined by clustering analyses using PATN (e.g., Belbin 1990, 1991) to determine patterns of damage and hence sequences of carcass tissue utilization. Data from complete and all other carcasses were combined, and dendrograms developed, using the Bray-Curtis association measure and the UPGMA fusion strategy (with b set at -0.1, Belbin 1990).

RESULTS

Tissue, organ and body masses. —Organ and tissue masses are compared (Fig. 1) with body masses of intact Adélie Penguin chicks (of varying ages) and that of an adult. Simple correlations between organ masses, and between organ and body masses in each individual, were generally strong and highly significant ($r = 0.92$ to 0.99, $P < 0.01$–0.001, $N = 8$–10), but correlations involving stomach mass (although significant) were somewhat reduced (e.g., with submandibular and neck tissue, $r = 0.732$, $P = 0.016$), presumably reflecting differences in included contents. Although maximum stomach mass in a chick examined here was only 83.6 g, food deliveries to chicks may be about 20% of body mass (Croxall and Lishman 1987) and some 470 g of krill may be delivered to a 1 kg chick (Trivelpiece et al. 1987).

Abdominal organs formed 18.8% (± 3.7 SD, $N = 9$) of the mean body

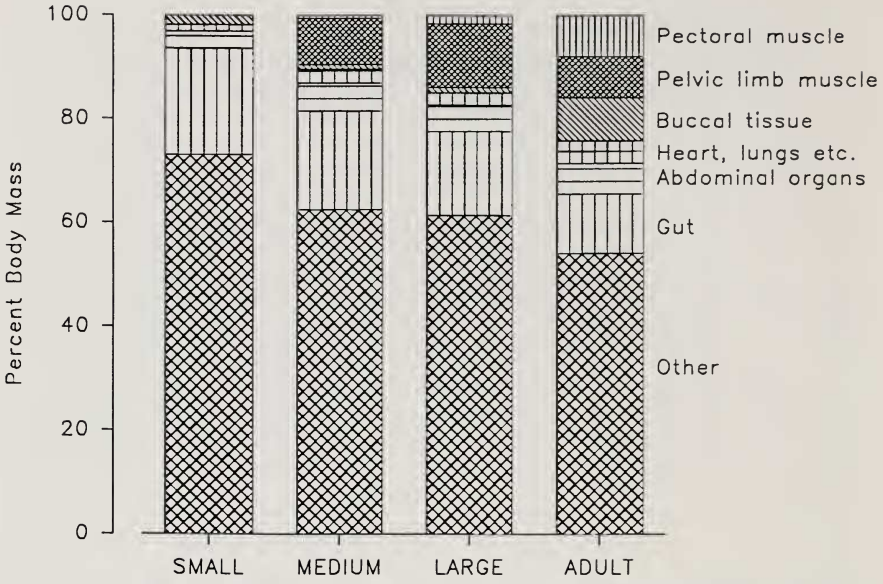

FIG. 1. Organ and tissue masses as percent of body mass in Adélie Penguins. One small chick (57.5 g), four medium-sized chicks (mean 261.9 g ± SD 114.4), four large chicks (780.5 g ± 273.3) and one adult (4370 g) were sampled.

mass. The stomach itself contributed 8.0% (±3.3, N = 10), the heart, lungs and associated vessels 4.4% (±1.1, N = 8), and the spleen, liver, kidney, adrenals and gonads 5.3% (±0.9, N = 9). Pelvic limb muscles (11.6%, ±1.7, N = 8) were important in determining the average carcass body mass, but pectoral muscles (2.1%, ±2.4, N = 8) and submandibular and ventral cervical soft tissues (1.8%, ±2.3, N = 10) were not.

Carcass utilization.—For the more extended series of 115 carcasses collected on Hop Island, 14 (12.2%, including 13 subadults from a previous season) had no obvious external damage and apparently had not been killed or fed on by skuas. External damage only was noted on 79 complete (i.e., not dismembered) corpses (chicks and subadults) from all sites, but of these most (71, 89.9%) had multiple injuries. Single areas of damage or attack were concentrated around the head or neck (seven instances). In corpses with more than surface damage, subsequent feeding was extensive and concentrated in the thoracic–abdominal regions. Thus, in the complete chick and subadult carcasses, of the 518 skin breaks and tissue or organ removal noted, 116 (22.4%) were in the head and neck region, while 283 (54.6%) involved the thoracic and abdominal skin, the underlying tissues and/or organs. In some instances, access to thoracic

material was achieved through abdominal skin breaks. Skuas paid little attention to the pectoral (8, 1.5%) and pelvic (35, 6.7%) regions, but did attack the pelvic limbs (84, 16.2%). At least 11 carcasses had broken spines, 12 broken necks, five had broken ribs, and three showed cranial breaks. There was no significant difference (t-test) apparent between mean numbers of damage areas in either the complete carcasses of chicks (7.57 $\pm$ 8.09) or those of subadults (7.37 $\pm$ 6.68), suggesting similar utilization patterns.

Increased feeding by skuas ensued around the abdomen and upper leg musculature, as indicated by the damaged penguin corpses (133 young and subadult, two adult) examined. Indeed, 489 (48.1%) instances of tissue damage or removal were in those areas. Removal of head (in 44 instances) and neck (24) apparently often followed initial feeding. Such destruction masked the possibly more extensive damage on the body parts removed. Examination of damage totals (discounting those involving removal of body parts) for major body areas (head, neck, thorax, pectoral, abdomen, pelvic and pelvic limb) showed significant differences (χ^2, $P < 0.0001$), with cell frequencies indicating that complete corpses had higher damage rates around the head and neck areas, and incomplete lower, than expected. Complete and incomplete carcasses had higher rates of damage in the pelvic limb area, but incomplete carcasses showed a higher incidence of damage, and complete carcasses lower, than expected in the pelvic area itself. Ultimately, all parts of the carcass were attacked, and remnant carcasses (cruciform) of leg and wing bones, and skull, were depleted of all soft tissues and/or dismembered.

This progression is also supported by pattern analyses. For all complete carcasses (Fig. 2), it is apparent that centers of damage exist around the head and neck, the thoracic region, and the abdomen (including the pelvis and pelvic limbs). Damage may be used to separate birds into four groups having tissue damage in the (1) head and neck region, (2) head and pelvic area, (3) neck, thorax, abdomen and pelvic area, and (4) those with damage around the pectoral region. Consideration of carcasses showing more extensive damage (Fig. 3) suggests that five groups exist, namely damage centered around the head (including its removal), a group with predominantly abdominal, pelvic and neck damage, a group showing thoracic and pectoral damage, one group having abdomen and pelvic areas removed, and a fifth group with major bone damage and removal.

DISCUSSION

Skuas are not well-adapted for flesh-eating. Unable to hold prey with their feet, they have to rip with the bill (Burton 1968). Nevertheless, throughout their range, South Polar Skuas are predators and/or scaven-

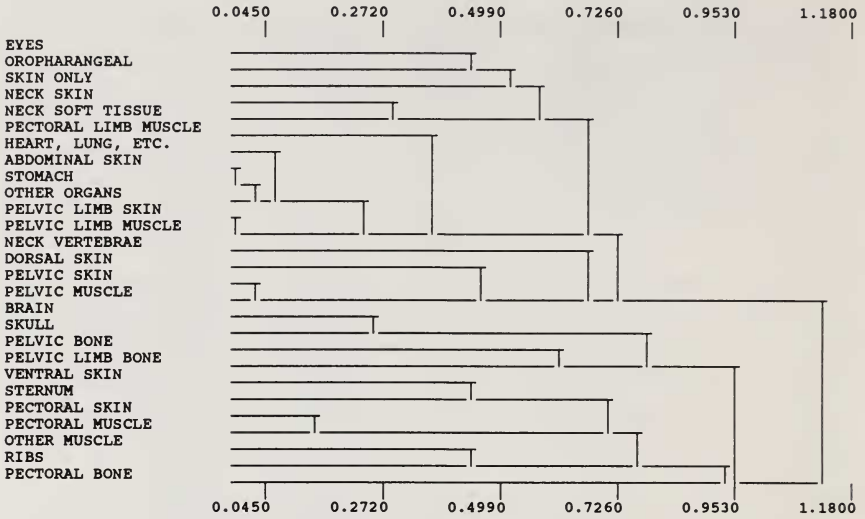

FIG. 2. Dendrogram showing clustering of areas of tissue damage in complete carcasses of Adélie Penguins (chicks and subadults) eaten by South Polar Skuas in the Vestfold Hills area, East Antarctica (Bray-Curtis association measure indicated, using Belbin 1990).

gers. Seabirds such as Adélie Penguins are included in their diet. In this study, Adélie Penguin carcasses with only external skin breaks, areas involved in procurement and killing or initial feeding, showed damage centered around the head, jaw, throat and eye. Bone damage may also have been associated with killing or later feeding. Various authors have suggested that skuas jump on terrestrial prey and drag young penguins away from creches. Initial attacks are then directed toward eyes, the skull or neck, with attention being paid to legs and the rectal area. Damage associated with removal of kidneys has also been noted (Wilson 1907, Sladen 1958, Burton 1968, Johnston 1973, Furness 1987, Robertson 1992). Very young Adélie Penguins are apparently eaten whole by skuas, or torn apart before ingestion, while carcasses of those three or more weeks of age are stripped to leave bones of the spine, pelvic girdle and limbs (Young 1963b, Müller-Schwarze and Müller-Schwarze 1973, 1977). Initial feeding in this study was concentrated, most particularly, in the thoracic and abdominal regions (Figs. 2 and 3), which may reflect both ease of access into soft tissue (thoracic material was also removed through abdominal skin breaks) and nutritional efficiency. Tissues in other body areas were then removed, although not necessarily in one feeding bout. Feeding on abdominal and thoracic organs may decrease carcass mass by some 40% and removal of pectoral and pelvic limb muscles by a further 14%. Carcass remnants from penguin chicks may represent only 8% of initial body mass

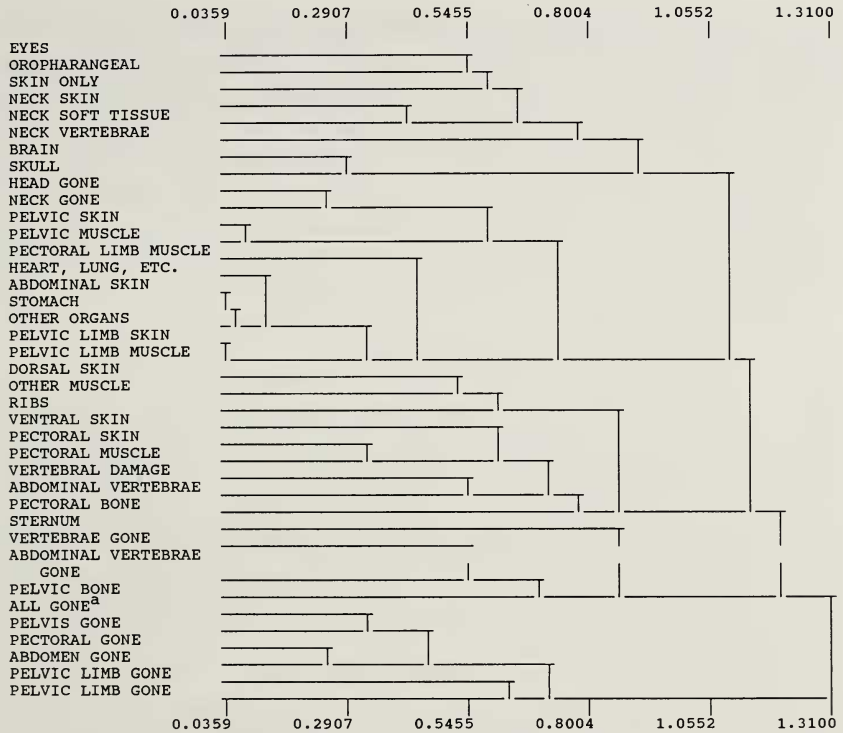

FIG. 3. Dendrogram showing clustering of areas of tissue damage and organ removal in Adélie Penguin carcasses eaten by South Polar Skuas in the Vestfold Hills area, East Antarctica (Bray-Curtis association measure indicated, using Belbin 1990). (a = whole pelvis removed.)

(Müller-Schwarze and Müller-Schwarze 1977), but Maher (1966) suggested that only 75% (i.e., some 645–790 g for birds sampled here) of a corpse was "edible."

Although the mean stomach mass in this series was some 47 g (and varied substantially with the age of the penguin), if stomach contents themselves represent a major food item (Müller-Schwarze and Müller-Schwarze 1977), then skuas may obtain up to 135 g of included food (mainly krill *Euphausia superba* and/or fish, predominantly *Pleuragramma antarcticum*) from a recently-fed chick in local colonies at about the time of these samples (Puddicombe and Johnstone 1988). Such foods may provide 3.8–5.4 (krill) to 4.8 (Dunn 1975) or 6.6–11.5 (fish) kJ/g wet weight (Clarke and Prince 1980). However, seabird eggs provide as much energy, and hatched chicks more as they develop. Short-tailed Shearwater (*Puffinus tenuirostris*) eggs provide 7.3 kJ/g wet weight, and chicks 5.2–

19.7 kJ/g (Fitzherbert 1985). Near fledging chicks of Double-crested Cormorants (*Phalacrocorax auritus*) may provide 9.2 (Dunn 1975) and Little Penguins (*Eudyptula minor*) 8.7 kJ/g (Gales and Green 1990). Fresh and recently-hatched chicks of Chinstrap Penguins (*Pygoscelis antarctica*) have calorific values of about 3.3 kJ/g and fledging chicks 9.2 kJ/g (Myrcha and Kaminski 1982). Increased fat reserves, rather than protein, would enhance the calorific value of chicks as prey, as would increased lipids in stomach fluids. Further, total calorific intake is improved by feeding from an individual chick rather than numbers of eggs. For this reason, it may be appropriate for skuas to move attention from eggs to chicks as they hatch and grow. On Magnetic Island, abandoned penguin eggs were not always eaten, although they were extensively scavenged before the hatching of chicks, which were not always eaten immediately after being killed.

Early in the skuas' breeding period, during incubation or when their chicks are small, penguin chicks may be killed but only lightly used by skuas (e.g., Brown Skua [*C. skua lonnbergi*], Hemmings 1990), with perhaps only the stomach being taken initially, before later carcass utilization (Melke 1975, Müller-Schwarze and Müller-Schwarze 1977, Furness 1987). This apparent surplus killing may allow the establishment of a larder that is managed as the breeding period continues (Pryor 1968, Müller-Schwarze and Müller-Schwarze 1973, Trillmich 1978). Such larders may provide for shortages of food after penguin chicks have fledged and departed, when developing skua chicks have increased food demands (and may scavenge by themselves within the feeding territory), or when adult, molted penguins leave breeding areas. Such corpses, and those of penguins dying during molt, may also provide food early in the following breeding season (indeed C. Pascoe, pers. comm. reported this at Hop Island in 1991/1992). The incidence of undamaged corpses of subadult penguins at Hop Island, from previous seasons, may support this. Such larders represent a management system particularly appropriate in Antarctic areas, where food deterioration rates are low.

Early in the season penguin chicks provide skuas an alternative to foraging for other foods (such as krill or fish, or other less-densely breeding avian prey), and later one providing more caloric value without extended foraging and associated energy expenditure. However, feeding on Adélie Penguin chicks depends on their availability, not only to skuas holding feeding territories which include breeding penguins but to others excluded from such areas. For skuas with ready access to chicks, management of carcasses (Müller-Schwarze and Müller-Schwarze 1973) may represent a useful strategy during the development of their own chicks, particularly since during the guard stages, penguin chicks may be less available (Maher 1966) and larger ones difficult to kill (Müller-Schwarze and Müller-Schwarze 1973). Although penguins chick carcasses contain more poten-

tial food mass and energy than individual alternative foods, they also represent a food reserve for times of shortages. Certainly such foraging is more energy efficient than kleptoparasitism (Maxson and Bernstein 1982). It may at times also be more efficient than extended flights in search of krill or fish. Young (1963b) reported periods away from the territory of up to 93 min, with some 140 g of fish being obtained in 52 min. In contrast, a skua took 6.5 min to kill a penguin chick of 1750–2000 g. For South Polar Skuas with penguins in their feeding territories, or for others without continued access to them, carcasses may be stripped with profit.

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